CURRENT LITERATURE

NOTES FOR STUDENTS

Mitosis in Osmunda.—Cytologists are familiar with the two outstanding views, associated respectively with the names of GRÉGOIRE and FARMER, regarding the method of chromosome reduction. According to the first view the doubleness of the spirem of the early heterotypic prophase, unlike that of the somatic prophase, is due to a lateral conjugation of threads representing entire chromosomes to form bivalents which are separated at the heterotypic mitosis, a new split functioning in the homotypic. According to the second view the doubleness is due to a split as in somatic mitosis; bivalents are formed by a conjugation of segments of this double spirem which separate in the first mitosis, while the original split functions in the second. A very complete statement of this latter interpretation has been given by Miss DIGBY[1] in a new account of mitosis in *Osmunda*.

In all the archesporial divisions, including the last, the chromosomes undergo a longitudinal splitting during early telophase. The homogeneous daughter threads become beaded as the split between them widens, and with many small connecting strands eventually form a faint resting reticulum which bears many small granules, and in which the limits of the individual chromosomes are indistinguishable. Most of the chromatin is collected in three or more nucleoli. In the succeeding prophase the reticulum resolves itself into a number of thin beaded linin threads; these run in parallel pairs and are regarded as the two reassociating halves of the chromosomes split in the preceding telophase. As the association becomes closer, the material of the threads is progressively concentrated, until it takes the form of a double spirem which segments into split chromosomes. These are separated into their component halves at anaphase and undergo a new splitting during telophase. Nuclei may go from the telophase of the last premeiotic division directly into the heterotypic prophase, or may pass through an intervening resting stage.

In the heterotypic prophase the reticulum gives rise to beaded "threads" which become more uniform spirems with a distinct parallelism, just as in the archesporial prophases. At this stage occurs synizesis, during which the reassociation of the parallel threads to form "filaments" is completed. From the contraction emerges a thick double spirem homologous with the double

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[1] DIGBY, L., On the archesporial and meiotic phases of *Osmunda*. Ann. Botany **33**:135–172. *pls. 8–12. fig. 1.* 1919.

spirem of the somatic prophase; the doubleness is believed to be the result of splitting in the last premeiotic telophase, and not to a conjugation of entire chromosomes. This double univalent spirem, which is more or less conspicuously beaded according to the fixing agent employed, is soon thrown into loops and the split becomes obscured. During the succeeding stages segments of the spirem (the "filaments"), although originally arranged end to end before segmentation, conjoin laterally in pairs to form the bivalent chromosomes, a process which is consummated in the second contraction. It is here that the conjugation of entire chromosomes occurs, whereas at the first contraction (synizesis) daughter halves of chromosomes are reassociated. As the second contraction loosens, the bivalents shorten and thicken and take up positions near the periphery of the nucleus (diakinesis). Only rarely at this stage can the temporarily obscured split of each component of the bivalent be detected.

As the bivalent takes its place upon the spindle, its univalent components become somewhat disjoined, and each again reveals the fission which had its origin in the last premeiotic telophase and was most conspicuous in the spirem of the early heterotypic prophases, and which marks the line of separation for the homotypic mitosis. As the univalent passes toward the pole, its halves widen out along this line of fission, giving the V-form characteristic of the heterotypic anaphase. During early telophase each daughter half of the split univalent undergoes a new longitudinal fission; this is homologous with the split occurring in the somatic telophase; after being obscured it reappears in the homotypic anaphase and functions in the post-homotypic division. The telophasic transformation of the chromosomes occurs as described for the archesporial divisions, and during interkinesis the individual chromosomes are indistinguishable.

The homotypic division is regarded as essentially a continuation of the last premeiotic division, since the doubleness of the chromosomes of the homotypic prophase is held to be the same as that of the last premeiotic telophase; the heterotypic division is consequently an interpolated process effecting numerical reduction. Although the events of the homotypic division are "involved in some obscurity," they seem to be in the main as follows. The threads derived from the fission of the daughter halves of the univalent chromosomes in the heterotypic telophase reassociate in pairs and form a number of chromatic masses, which later take the form of loosely associated daughter univalents; these arrange themselves more or less independently on the spindle. During their anaphasic separation (along the line marked out in the last premeiotic telophase) the fission which had its origin during the close of the heterotypic mitosis, and which is to function in the post-homotypic mitosis, reappears. The chromosomes at telophase take the form of double beaded threads which establish the resting reticulum as in the archesporial mitoses.

Although in substantial agreement with the conclusions of FARMER and MOORE,[2] this interpretation of maturation is directly opposed to that of GRÉGOIRE[3] and YAMANOUCHI,[4] who hold that the double heterotypic spirem in *Osmunda* arises from a conjugation of thin threads, each representing an entire chromosome, as stated in the first paragraph of this review. The GRÉGOIRE school charges the FARMER school with a misinterpretation of the presynaptic stages, while the latter charges the former with a neglect of the second contraction stages. It is not to be denied that the view stated fully by Miss DIGBY has certain advantages: it allows one interpretation to be placed upon the double spirem in both somatic and heterotypic prophases, irrespective of the exact time at which the split originates, and it also helps to explain the sudden appearance of the split for the second maturation mitosis in the anaphase of the first.

This question, however, must be settled primarily by direct evidence. It is obvious that its solution depends upon the exact manner in which the telophasic transformation of the chromosomes and the derivation of the latter from the reticulum in prophase are accomplished. It is granted by both sides that the alveolar or reticulate condition in which the chromosomes are found in late telophase is continuous with the similar condition seen in the succeeding prophase. If, therefore, it is true (1) that the telophasic transformation (alveolization) represents a true splitting, and (2) that the early prophasic reticulate condition passes directly into the double spirem, it follows that this doubleness in every prophase is due to the fission which originated in the preceding telophase, as held by Miss DIGBY. Contrary to the statement of that author, however, workers on mitosis are not at all generally agreed that the evolution of the chromosomes is that stated in (1) and (2). In his investigation of somatic mitosis in *Vicia Faba* for the purpose of elucidating these points, the reviewer,[5] contrary to the findings of FRASER and SNELL,[6] FRASER,[7] and others, showed not only that the telophasic alveolization is too irregular to permit of its being regarded as a splitting, but also that the reticulate condition of the prophase, instead of developing directly into the definitive split, gives rise to simple thin threads in which a new split develops. From

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[2] FARMER, J. B., and MOORE, J. E. S., On the meiotic phases in animals and plants. Quart. Jour. Micr. Sci. **48**:489–557. *pls. 34–41*. 1905.

[3] GRÉGOIRE, V., La formation des gemini hétérotypiques dans les végétaux. La Cellule **24**:369–420. *pls. 2*. 1907.

[4] YAMANOUCHI, S., Chromosomes in *Osmunda*. BOT. GAZ. **49**:1–12. *pl. 1*. 1910.

[5] SHARP, L. W., Somatic chromosomes in *Vicia*. La Cellule **29**:297–331. *pls. 2*. 1913.

[6] FRASER, H. C. I., and SNELL, J., The vegetative divisions in *Vicia Faba*. Ann. Botany **25**:845–855. *pls. 62, 63*. 1911.

[7] FRASER, H. C. I., The behavior of the chromatin in the meiotic divisions of *Vicia Faba*. Ann. Botany **28**:633–642. *pls. 43, 44*. 1914.

this it cannot be concluded that in no form does the split develop directly from the early reticulate structures, or that the telophasic alveolization, although irregular, may not later become so equalized as to constitute the first stages of the split; but it does follow that it is quite unsafe to use the principle of telophasic splitting as a premise from which to draw the conclusion that the approximation of thin threads in the early heterotypic prophase represents the reassociation of the halves of a single split chromosome. Although it is well to emphasize the importance of the premeiotic telophase, the ultimate solution of this perplexing problem must be reached mainly through a more refined analysis of those prophasic changes which have led a long list of investigators to the conclusion that the early heterotypic association of threads represents a conjugation of entire chromosomes which separate at the heterotypic division. To the reviewer the figures so far given by the English cytologists do not prove the theory they advocate.—L. W. SHARP.

Carbohydrate economy of cacti.—A distinct contribution to our knowledge of the carbohydrates in plants in general, and in the succulents in particular, is the report of SPOEHR'S investigations at the Desert Laboratory.[8] The methods employed give us what is probably the most complete analysis of the carbohydrates of a single plant tissue that we have, values for no less than 11 different groups of carbohydrates being ascertained, partly by direct determinations and partly by calculation.

The monograph is prefaced by a rather thorough discussion of carbohydrate metabolism in plants, and of the transformations of the carbohydrates under the influence of acid, alkali, oxidation, and enzymes, and of the energy relations of the products of these transformations. Then follows a description of the methods employed. *Opuntia phaeacantha* and *O. versicolor* furnished material for the studies. In preparing the tissues for carbohydrate analysis they were ground in a meat chopper and placed in an oven at 98° C. The precaution of DAVIS and DAISH of plunging the tissue into boiling alcohol was not deemed necessary. The disaccharides and polysaccharides were hydrolyzed by boiling with 1 per cent hydrochloric acid for 3 hours. All sugar determinations were made volumetrically with Fehling's solution. The pentoses were determined after fermenting away the hexoses with bakers' yeast.

The polysaccharides of the cactus are starch and xylan. The mucilage of *Opuntia* consists of 34.1 per cent d-glucose and 65.9 per cent l-xylose. Associated with it there is probably an acid. Glucuronic acid was found as a constituent of the sap. The formation of mucilage in special large cells could be watched under the microscope under certain conditions.

The relative abundance of the different groups of carbohydrates and also of water is profoundly affected by the seasonal variations of the external

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[8] SPOEHR, H. A., The carbohydrate economy of the cacti. Carnegie Institution of Washington. Publ. 287. pp. 79. 1919.